Remarks

Reconsideration of the present application is respectfully requested. Claims 23, 24, 25, 26, and 27 have been canceled in this paper. Claim 13 is amended herein to place the claim in proper idiomatic form. No change in claim scope is effected by the amendment, and it is submitted that all statutory requirements for patentability are compiled with, regardless of whether this change is made or not. It is submitted that the remaining claims under consideration are in condition of allowance, particularly in view of the following remarks.

All claims that remain, namely claims 3-4, 6-7, 13-22, 33, 35-36, and 39 stand rejected under 35 U.S.C. §103(a) as unpatentable over Cadien et al. (U.S. Patent no. 5,516,346) in view of Kaufman et al. (U.S. Patent no. 6,063,306).

The examiner purports that Cadien et al. teaches a concave insulating film formed on a substrate forming a barrier layer, forming an interconnect metal film over the surface, polishing the surface by a first and second polishing process until the surface of the insulating film, other than the concave, is exposed. Also, the examiner purports that Cadien et al uses a polishing slurry comprising silica polishing material, an inorganic salt, and an oxidizing agent.

The examiner further indicated that "Cadien does not teach the polishing ratio as claimed", however, that is not significant to the examiner, since the examiner contends that Cadien et al. "[controls] the etching rate of the barrier layer and the interconnect metal and [controls] the etching rate of the interconnect metal and the insulating film". For this proposition, the examiner cites Cadien et al. at col. 7, lines 50-65, and col. 8 at lines 17-45, and col. 9 at lines 1-45. However, Cadien et al. does not teach any particular polishing rate anywhere in its disclosure.

Concerning Kaufman, et al., the examiner indicated that:

> "Kaufman et al. shows applying a first slurry comprising an alkanolamine (such as, triethanolamine) and second slurry comprising carboxylic acid (such as tartaric acid) in a polishing process as well known in the art. Kaufman et al. also teaches the slurry comprising benzotriazole and the barrier film being a tantalum-containing metal film (Abstract, col. 4, lines 15-67, col. 6, lines 2-45, col. 8, lines 20-45, col. 10, lines 50-65, TABLE 1, 4, col. 15, lines 25-65, col. 16, lines 48-67)."

First of all, it is observed that while Cadien et al. might disclose the factors that may allow the practitioner of Cadien et al. to control the etching rate of the barrier layer, it is uncontroverted that Cadien et al. does not disclose that the polishing rate ratio of the interconnect metal to the barrier metal is within 1 to 3 inclusive. The applicants have found that certain advantages are attained when the ratio is maintained within this range.

At pages 14-15 of the present specification, it is indicated that polishing rate ratio bears upon the quality of the finished product, and that advantages relating to same are attained where the polishing rate ratio is within the applicants' claimed range. If the polishing rate ratio of the polishing slurry (interconnect metal/barrier metal) is less than 1, i.e., if the polishing rate for the interconnect metal film is smaller than that for the barrier metal film, complete removal of the partially remaining interconnect metal film is difficult, which may result in short-circuits between interconnects caused by an insufficiently polished part. Also, a reduction in a throughput may be realized, since polishing must be practiced for a longer period of time to prevent the short-circuit. Still further, excessive polishing that may take place after an excessive polishing period during the first polishing can lead to erosion of an area of the already exposed barrier metal or insulating film.

As for the upper end of the range, if the polishing rate ratio of the polishing slurry (interconnect metal/barrier metal) is greater than 3, i.e., if the polishing rate for the interconnect metal film is considerably larger than that for the barrier metal film, the interconnect metal within the concave is excessively polished, resulting in problems such as tendency to dishing, short-circuits (in this instance, because the polishing rate for the barrier metal is sufficiently small to leave the barrier metal on the insulating film), and a reduced throughput or further dishing due to a longer polishing period for preventing the short-circuit.

Thus, when in the second polishing step CMP is conducted using a polishing slurry controlling a polishing rate ratio (interconnect metal/barrier metal) of 1 to 3 inclusive, there may be formed a damascene interconnection in an improved throughput without leaving the metal on the insulating film (other than the concave) and without dishing while preventing erosion throughout the first and the second polishing steps.

In summary, short circuits between interconnects are prevalent where the polishing ratio is less than 1, and there is a tendency towards discharge, short circuits, and reduced throughput where the ratio is above 3.

The applicant submits that the claims as presently presented are allowable in their present form. Cadien et al. simply makes no disclosure that relates the polishing rate ratio of the interconnect metal layer to the barrier metal layer, and the effects of same on the resulting product. Cadien et al. certainly does not disclose the beneficial effect of maintaining polishing rate ratio as indicated in the present application and claims. In view of the deficiencies of Cadien with respect to this element of the claimed invention, it is submitted that this rejection is traversed.

There are additional reasons that support patentability over the combined teachings of Cadien et al. and Kaufman et al. In a first polishing method according to claim 3 or 6, the first polishing step is conducted such that the interconnect metal film (Cu-based film) partially remains on the surface in locations other than in the concave portion (see p. 12, line 9 – p. 15, line 24). On the contrary, Cadien et al. discloses that the first polishing step continues until substantially all of the W (tungsten) layer formed on TiN layer is removed (see column 8, lines 17-21).

Cadien et al. discloses a polishing slurry comprising an inorganic salt (fluoride salt) employed as a complexing agent to complex with Ti found in a Ti layer (see column 8, lines 53-56). However, in the present invention, Ta is used as a barrier metal, not Ti (see claim 39). Cadien et al. does not teach that the slurry including the inorganic salt is effective at polishing a layered substrate employing a Ta layer as a barrier layer.

With respect to the teachings of Kaufman et al., it is observed that this reference does not disclose at what time the first polishing step is terminated. As recited in claim 13 of the present application, the first polishing step is conducted such that the interconnect metal film does not remain on the surface except in the concave portion (that is all of the interconnect metal film other than in the concave portion is removed) while the barrier metal film is not completely removed (that is the barrier metal film remains). Furthermore, the second slurry used in the second polishing step has a polishing-rate ratio of the interconnect metal to the barrier metal of 1 or less (see p. 16, line 1 – p. 17, line 23).

When the interconnect metal film remains on the surface other than in the concave portion after the first polishing step, complete removal of the remaining interconnect metal film in the second polishing step is difficult because the low polishing-rate ratio of the interconnect

metal to the barrier metal of the second slurry. This may cause problems, such as short-circuit relating to an insufficiently polished part, reduction in throughput because the time period in which polishing is practiced must be longer for preventing the short-circuit, and erosion resulting in an area of already exposed barrier metal or insulating film that was exposed in the first polishing step, due to the longer polishing period.

The first slurry, which contains alkanolamine, can reduce the polishing rate for the barrier metal film while increasing the difference in the polishing rate between the barrier metal film and the interconnect metal film in order to enhance the function of the barrier metal film as a polishing "stopper". Thus, the interconnect metal film is completely removed without realizing the above problems.

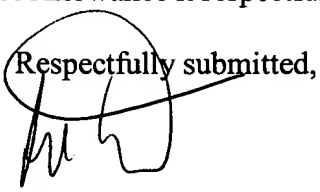
Since the barrier metal (Ta-based metal) is chemically much more stable than the interconnect metal (Cu-based metal), a polishing-rate ratio of the interconnect metal to the barrier metal of 1 or less has previously been achieved by reducing the contribution of chemical polishing; that is, by reducing the presence of an oxidizing agent or by adding an antioxidant to reduce a polishing rate for the interconnect metal film. In this technique, a polishing rate for the barrier metal film remains at a relatively low value and tends to produce an insufficiently polished part, which may lead to short-circuiting. On the other hand, an increase in the polishing time for preventing this problem may lead to other problems, such as reduced throughput. Also, excessive strengthening of mechanical polishing may cause problems such as scratches or erosion in the polished surface. Hence, the second polishing step in the second polishing method employs a polishing slurry which can control a polishing-rate ratio of the interconnect metal to the barrier metal to a desired level by increasing the polishing rate for the barrier metal film.

Thus, the composition according to claims 16-19 is suited for use as the second slurry (see p. 20, line 19 – p. 21, line 25).

Accordingly, Kaufman et al. is deficient with respect to the time where the first polishing step is ceased in the method of claim 13, nor does it teach the second slurry composition of claims 16-19.

Based on the foregoing, it is respectfully submitted that all the claims of the present application contain patentable subject matter and a Notice of Allowance it respectfully solicited.

Respectfully submitted,



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